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The authors of this study conducted an investigation of ventilatory function in 344 nuclear families in a representative population sample in Tucson, Arizona. Household aggregation of body mass was investigated as a possible confounding factor in the reported association between impaired lung function and parental smoking. The authors report that "when household aggregation of body mass was taken into account, there was no relationship of children's pulmonary function values to parental smoking." The study concludes with the statement that "[i]t must be concluded that passive smoking in the family, usually due to parental smoking habits, does not seriously affect permanent markers of respiratory disease such as pulmonary function."

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THE EFFECT OF PASSIVE SMOKING ON PULMONARY FUNCTION IN CHILDREN

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A study of ventilatory function was conducted in 344 nuclear families in a representative community population sample in Tucson, AZ. Household aggregation of pulmonary function, which is dependent on household aggregation of body mass, might affect the relationship of children's pulmonary function to parental smoking. When household aggregation of body mass was taken into account, there was no relationship of children's pulmonary function values to parental smoking. The trend, in the opposite direction, was similar to that found by Speizer *et al.* (1980a), but was not significant in this study. It must be concluded that passive smoking in the family, usually due to parental smoking habits, does not seriously affect permanent markers of respiratory disease such as pulmonary function.

Introduction

There has been some controversy surrounding the issue of whether passive smoking in households affects the respiratory health of children (NRC, 1981). Some investigators have reported that childhood symptom rates appear related to parental smoking, whereas others disagree. However, it is better to utilize pulmonary function to determine this effect, inasmuch as symptom reporting may show tendencies for parental biases (Cederlof and Colley, 1974; Lebowitz and Burrows, 1976; Schilling *et al.*, 1977). One study by Tager *et al.* (1979) showed the effect of parental smoking on FEV₁, utilizing Z scores. A similar analysis from the same laboratory in six other, different populations (Speizer *et al.*, 1980a) showed opposite results. Tager *et al.* (1976) also showed that there was household aggregation of pulmonary function values, which might influence such a relationship. This study has demonstrated the relationship of active smoking to ventilatory impairment (Knudson *et al.*, 1976; Burrows *et al.*, 1977), as has been found by others.

This paper attempts to examine the effects of parental smoking on children's pulmonary flow and volumes after correcting for any familial aggregation of ventilatory function and body size.

Methods

The Tucson Epidemiological Study of Airways Obstructive Diseases, which provided the data base for

these analyses, has been described previously (Lebowitz *et al.*, 1975). Briefly, it is a multistage stratified cluster sample of white non-Mexican-Americans in the Tucson area, where stratification was on age of head of household and on social status. Of the 1655 families studied (approximately 3800 individuals), families with children biologically related to the parents were chosen; these represented 344 households and about one-half of the population (1400). In the first year of this study (1972-1973), pulmonary function tests had been satisfactorily completed on over 90% of those age 6 and over using techniques previously described (Knudson *et al.*, 1976). Smoking habits in adults have been described previously (Burrows *et al.*, 1977); they are similar to those found elsewhere and cover the whole range of amount and duration of smoking.

These nuclear families were divided also into parent-child, spouse, and sibling pairs, the former using oldest children, by sex. Z scores [standard normal deviates $Z_i = (x_i - \bar{x})/s$, for i individuals and j age-sex groups] were calculated for forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), maximum flow at 50% of the vital capacity ($V_{50\%}$), and maximum flow at 75% of the expired vital capacity ($V_{75\%}$), within each sex-age group represented in the parent-child pairs. The Z scores were used in analyses of variance to correct for genetic components of body mass in pulmonary function parameters and to detect relationships between parental smoking and children's pulmonary function.

Most houses in this study, as determined by survey, are 1800–2400 ft², not more than 20 years old, have typical 8 ft ceilings, have screened windows, and have central heating and air cooling (usually with filters for both systems). They are kept relatively closed in summer and winter, but are somewhat more open in spring and fall. Air exchange rates have not been measured in this study, but are estimated using published information (NRC, 1981) at between 0.4 and 2.0 per hour, depending on season and use of forced air systems. Indoor pollutant levels were not measured in all of these houses as part of this study. Infiltration of suspended particulate has been measured in about 41 houses (Lebowitz *et al.*, 1982) and is low, though indoor generations is not. Carbon monoxide (CO) indoors and out has been also measured (Lebowitz *et al.*, 1982) and are low as well. The use of types of stoves has been measured in only some families (Lebowitz *et al.*, 1982). Outdoor levels of particulate alone are high in this area, but it is a silica quartz particulate. Nitrogen dioxide and CO are variable, but not in excess of NAAQS (Pima County, 1981).

Results

It was found that there was a household aggregation of pulmonary function values and of body size. Body size is the key determinant of ventilatory function values (Knudson *et al.*, 1976). When the household aggregation of body size was corrected, there was no household aggregation of pulmonary function that was still significant. Therefore, all pulmonary function values were expressed as percent predicted where the children's prediction equations use their own body size values, their age, and the body size values of their parents. Body size values used included height, weight, sitting height, and the ponderal index (H/W 1/3). Parents' pulmonary

function values were expressed as percent predicted, where the prediction equations used their body size values and their ages. Z scores were then calculated from these percent-predicted values for the age and sex groups (see above).

Analyses of parent-child, spouse, and sibling pairs by the smoking habits of the family members did not show any significant correlations of passive smoking with pulmonary function. This was true whether children's smoking or not smoking was accounted for, and was also true regardless of whether the parents had airway obstructive disease or abnormal pulmonary function tests. It was also independent of family size. Analyses of variance were performed for the children's pulmonary function test values by smoking in the household, by whether both parents smoked, or whether the mother smoked, father smoked, or neither. The total number of nuclear families was reduced to 271 when both parents and all the children age 6 and over in the household had satisfactory pulmonary function data. As can be seen in Table 1, none of the results were statistically significant. Analysis by amount of parental smoking yielded similar results.

In subsequent years of this study, further symptom information and history was collected. Analysis of these data in relation to passive smoking, using previous methods (Lebowitz and Burrows, 1976), indicated no relation to present or past symptoms, including persistent wheeze or early childhood lower respiratory tract illness. Further analysis awaits collection of more longitudinal ventilatory function measurements on the children.

Discussion

The effects of similar pollutants (specifically NO_x, CO) from the use of gas stoves on children's and adults'

Table 1. Children's pulmonary function by parental smoking in nuclear families.

| Parental Smoking | n | FEV ₁ (Z-score)* | | FVC (Z-score) | |
|------------------|-----|--------------------------------|-------|--------------------------------|-------|
| | | Mean | SD** | Mean | SD |
| Neither smokes | 48 | -0.121 | 0.993 | -0.082 | 0.997 |
| Mother smokes | 35 | -0.157 | 0.812 | -0.157 | 0.925 |
| Father smokes | 92 | -0.042 | 0.970 | -0.059 | 0.913 |
| Both smoke | 96 | +0.232 | 1.059 | +0.186 | 1.062 |
| Total | 271 | 0.026 | 0.996 | 0.011 | 0.988 |
| ANOVA: | | p = 0.0796 | | p = 0.1798 | |
| | | V _{max} 50% (Z-score) | | V _{max} 75% (Z-score) | |
| | | Mean | SD | Mean | SD |
| Neither smokes | 48 | -0.160 | 1.194 | -0.075 | 1.058 |
| Mother smokes | 35 | -0.147 | 0.848 | +0.004 | 0.888 |
| Father smokes | 92 | -0.174 | 0.945 | -0.173 | 1.011 |
| Both smoke | 96 | +0.150 | 0.985 | +0.202 | 0.972 |
| Total | 271 | -0.0002 | 0.998 | -0.0001 | 0.998 |
| ANOVA: | | p = 0.2443 | | p = 0.072 | |

*See text for explanation.

**SD = standard deviation.

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symptoms and pulmonary function were explored separately, inasmuch as previous studies indicate such potential effects (Speizer *et al.*, 1980b; Comstock *et al.*, 1981). In a substudy, gas stove use was related to acute symptoms only. Analysis in relation to chronic lung disease and ventilatory function had been performed on the total population of 1655 families; gas stove usage was not related to these measures of disease (Lebowitz, 1977). In that same study, it was shown that ambient outdoor particulate matter was slightly related to those measures of disease, but household size and type of house were not (after controlling for socioeconomic status). Socioeconomic status has little independent contribution to pulmonary function (or disease) once more important factors are considered, such as active smoking (Lebowitz, 1982). Thus, these other factors were not part of the analyses reported herein.

It is possible that correction for family body size concordance is not always necessary (Schilling *et al.*, 1977; Speizer *et al.*, 1980a, 1980b). The presence of persistent symptoms, such as wheeze, may be important in some populations (Weiss *et al.*, 1980), but were not in this population. However, consideration of fuel used for heating and cooking is necessary, especially when passive smoke appears important (Speizer *et al.*, 1980a, 1980b; Comstock *et al.*, 1981; NRC, 1981). Results, especially in lower socioeconomic classes or in developing countries, could be misleading otherwise. On the other hand, there still may be an effect of passive smoking, even when accounting for other exposures, in some circumstances and/or some communities, dependent on environmental circumstances, home ventilation factors, and social class.

A more extensive discussion of these factors and their interactions can be found in the National Research Council report (1981) and in an editorial by Frank and Lebowitz (1981).

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